Inclusive Search for Standard Model Higgs Boson Production in the WW Decay Channel Using the CDF II Detector

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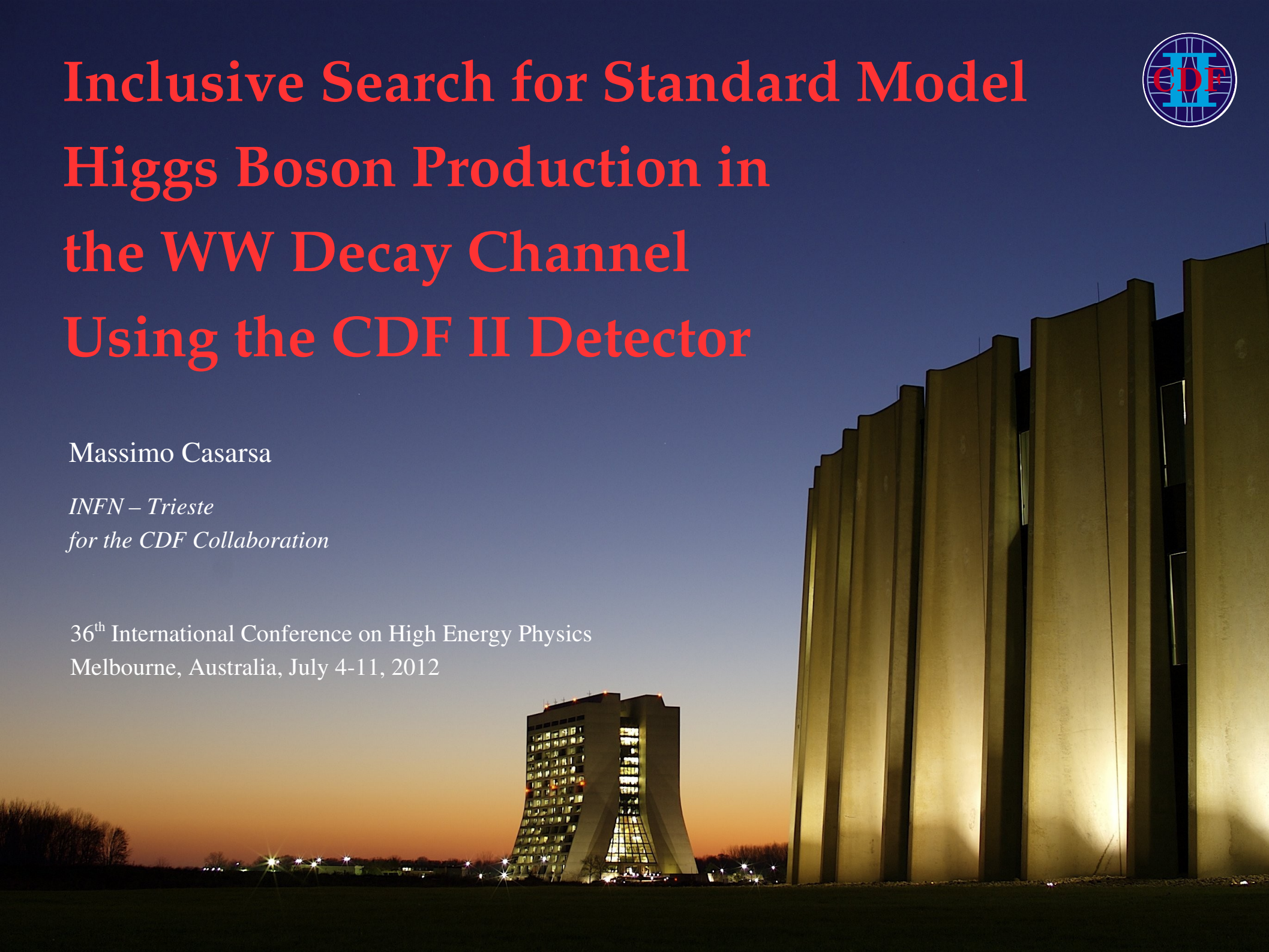
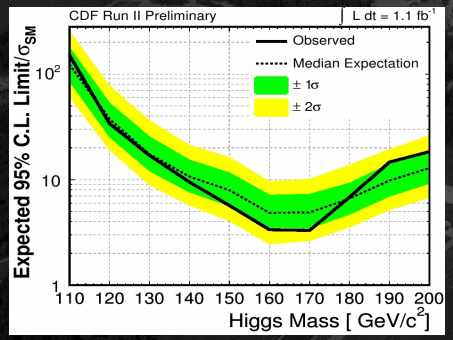


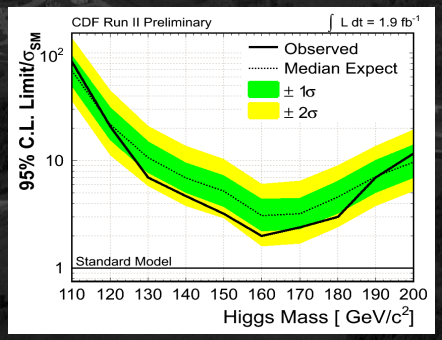
Flashback

- At the Tevatron the H → WW decay represents the golden search channel for a high-mass Standard Model Higgs boson.
- This search has a long history, which dates back to many fb^{-1} ago ...

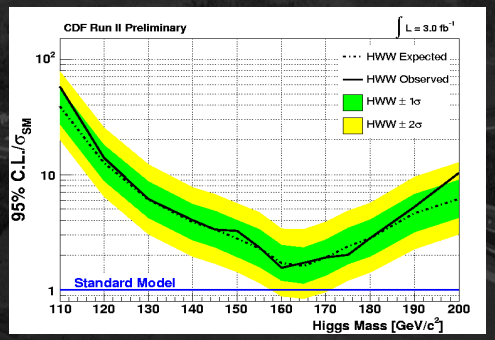
1 fb^{-1}



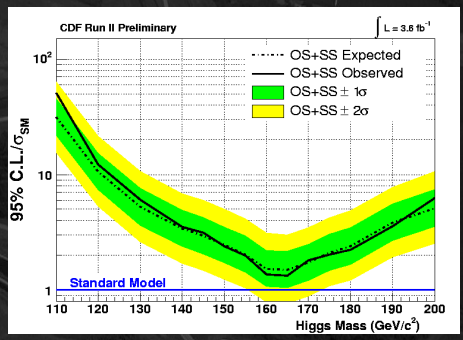
2 fb^{-1}



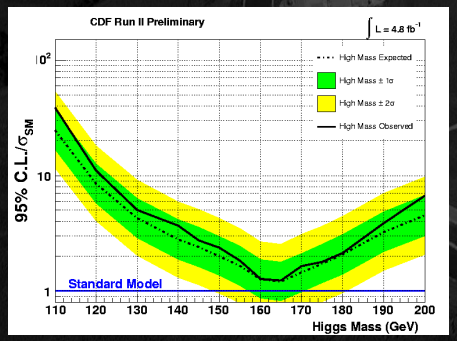
3 fb^{-1}



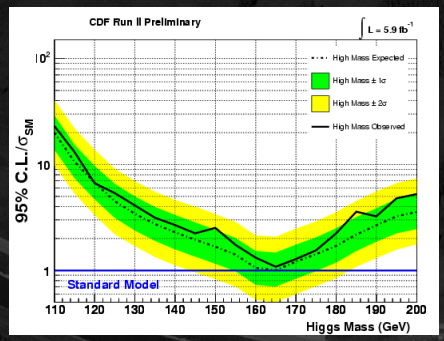
4 fb^{-1}



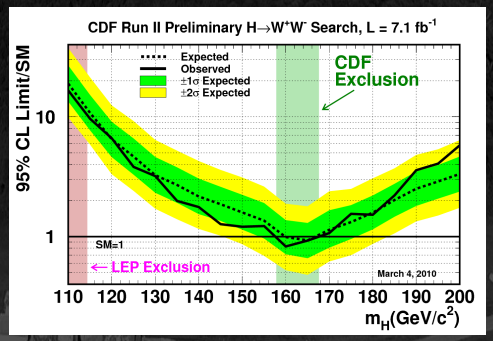
5 fb^{-1}



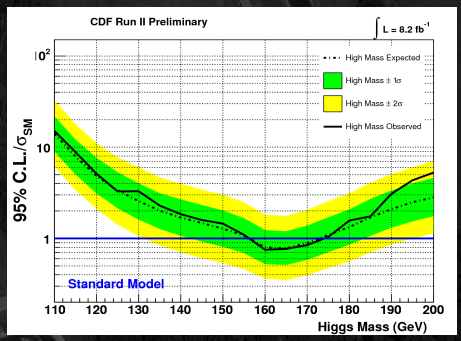
6 fb^{-1}



7 fb^{-1}



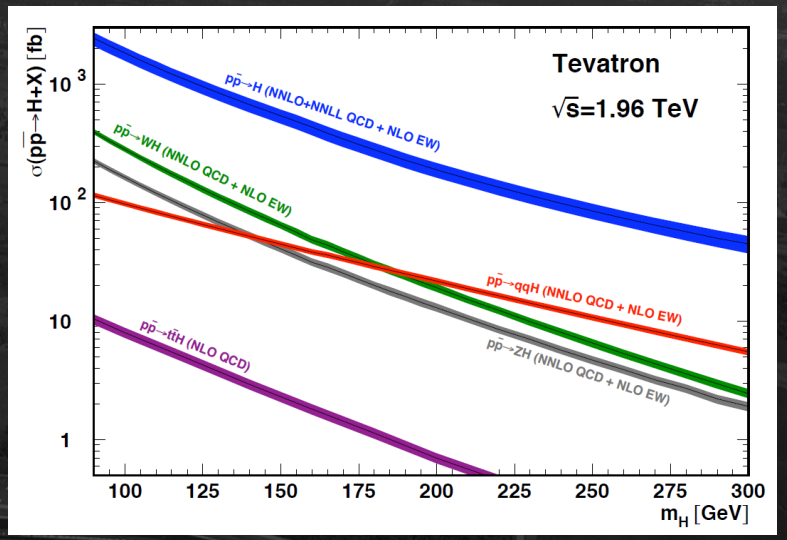
8 fb^{-1}

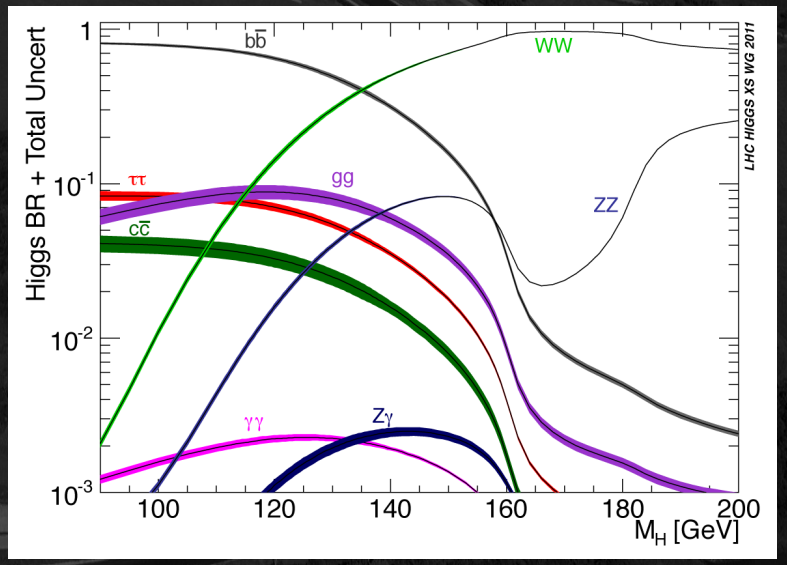


- Today I'm presenting the results on the full CDF Run II dataset.

Overview of the H→WW search channel

- Given the SM Higgs $p\bar{p}$ production σ_H at 1.96 TeV, searches for a SM Higgs are most sensitive in the range 100-200 GeV/c^2.
- The WW final state dominates for masses $m_H > 135$ GeV/c^2.
- Pros:
  - WW takes advantage of the direct $gg \rightarrow H$ production process;
  - final states with high-p_T leptons provide relatively clean experimental signatures.
- Cons:
  - Only a partial candidate reconstruction is achievable due to the escaping neutrinos.





Search strategy

- Search for all the SM Higgs production modes: $gg \rightarrow H$, WH, ZH, VBF (in 10 fb^{-1} produced 270 evts for $m_H = 125$ GeV/c^2 and 485 evts for $m_H = 165$ GeV/c^2).
- Loose kinematical event selection, followed by MVA techniques for a more effective signal-background separation.
- To inhance sensitivity, analysis conducted on multiple independent data samples, whose selection is targeted to specific production mechanisms:
  - opposite-sign dileptons with 0 or 1 jet;
  - opposite-sign dileptons with low $M_{\ell\ell}$;
  - opposite-sign e-τ_{had} and μ-τ_{had};

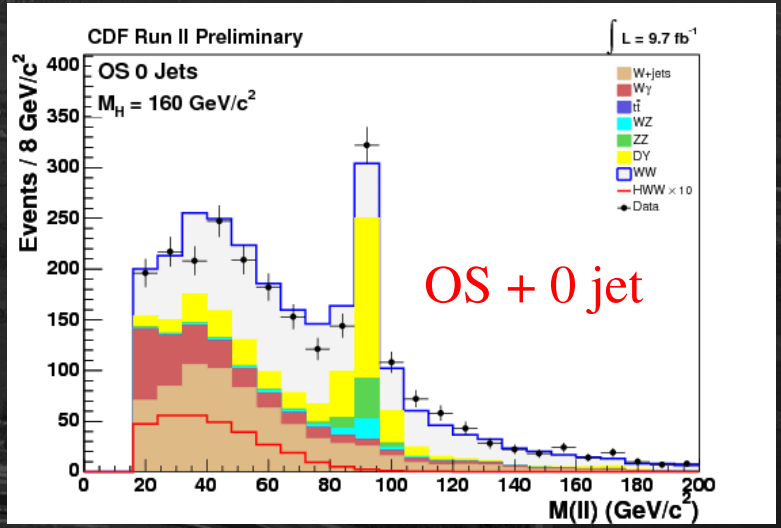
  } most sensitive to direct $gg \rightarrow H$ production

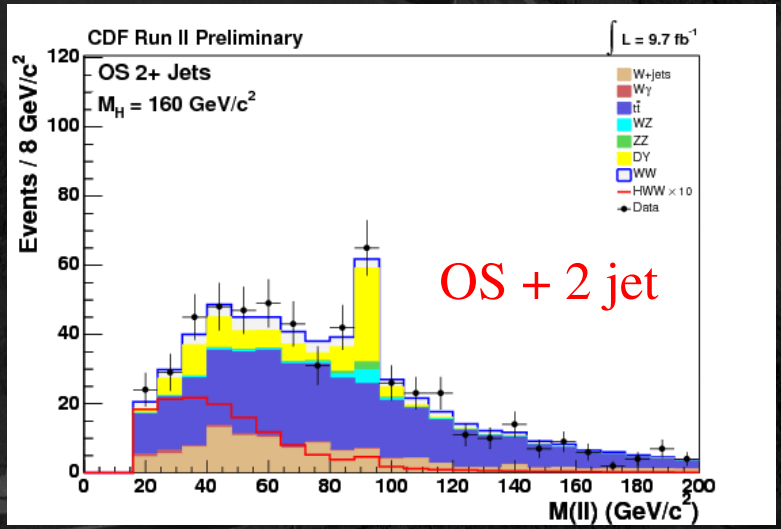
  - opposite-sign dileptons with 2 or more jets
  - same-sign dileptons with 1 or more jets;
  - trileptons.

  } most sensitive to associated WH and ZH production
- Results from different channels are then combined together.

Event selection

- Used 9.7 fb^{-1} of $p\bar{p}$ data collected by the CDF detector with single high-p_T electron and muon triggers.
- Basic event selection:
  - two or three charged leptons originating from the same vertex: $p_T > 20$ GeV/c for trigger leptons, $p_T > 10$ GeV/c otherwise;
  - large missing transverse energy.
- Globally expected:
  - ~76 signal events at 165 GeV/c^2 (~18 events at 125 GeV/c^2);
  - 5960 background events.



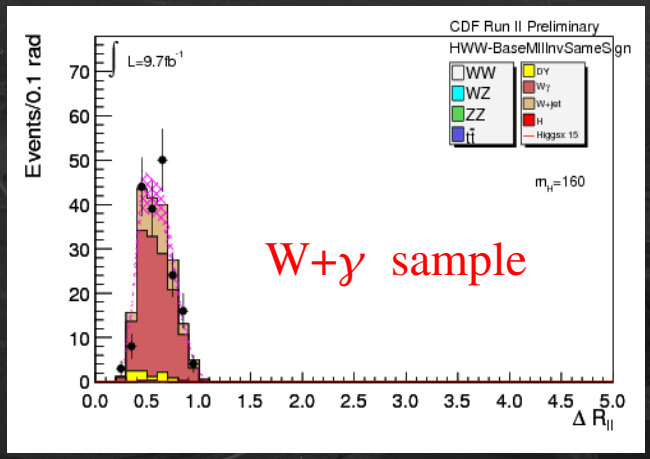


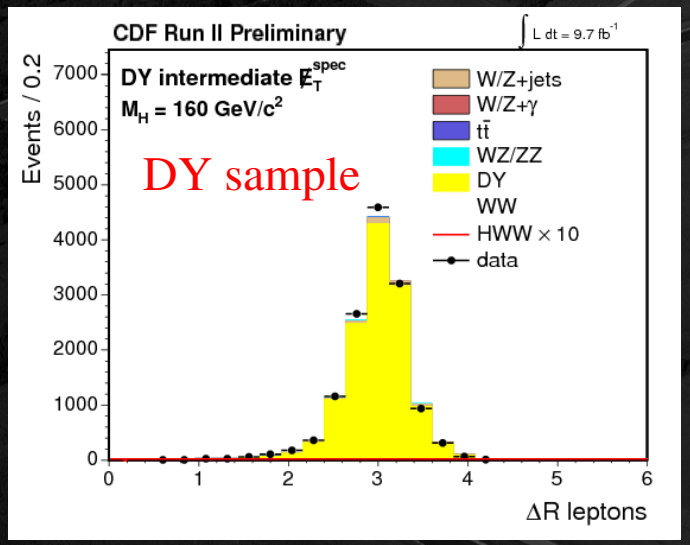
Signal and background modeling

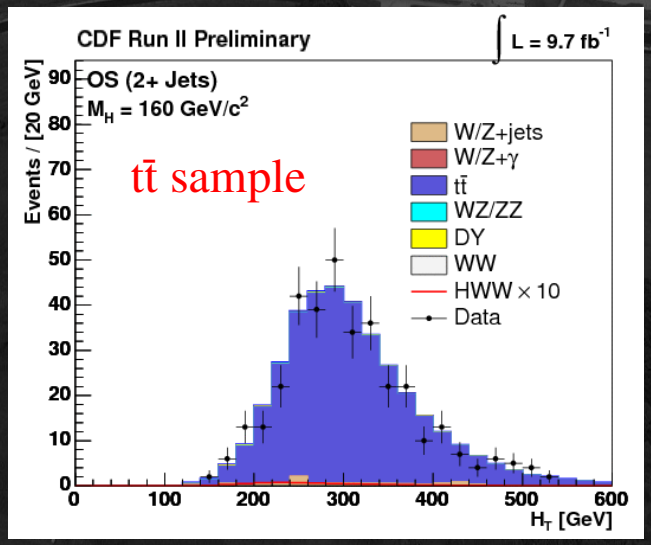
- In order to exploit at best the kinematical differences to discriminate signal and backgrounds, a very accurate modeling for all processes is needed.
- Higgs signals: PYTHIA.
- Standard Model backgrounds:
  - WW: MC@NLO, PYTHIA, ALPGEN;
  - WZ, ZZ: PYTHIA, ALPGEN;
  - Drell-Yan: PYTHIA, ALPGEN, MADGRAPH;
  - $t\bar{t}$: PYTHIA;
  - W/Z + γ: Baur-Berger generator, MADGRAPH;
  - W/Z + jets: data driven, ALPGEN;
  - dijet, jet + γ: data driven.
- Monte Carlo samples are normalized to the highest-order theoretical cross-section calculation available.

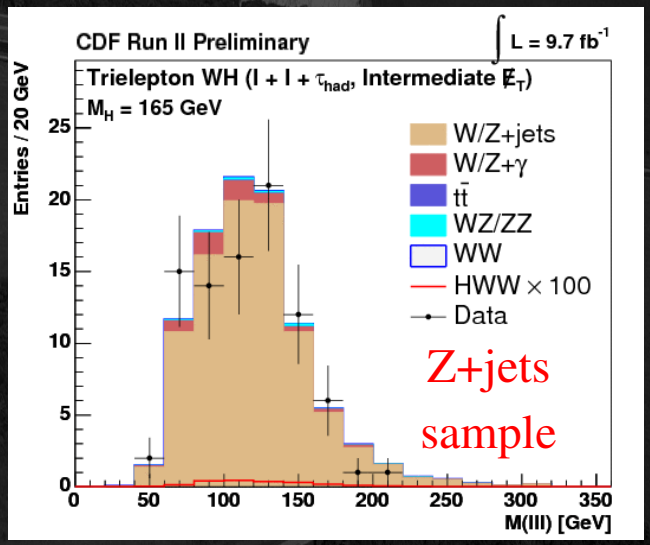
Control samples

- Selected background-enriched samples in data to tune/check the modeling of specific background processes:
  - similar selection to the search sample;
  - negligible signal content.





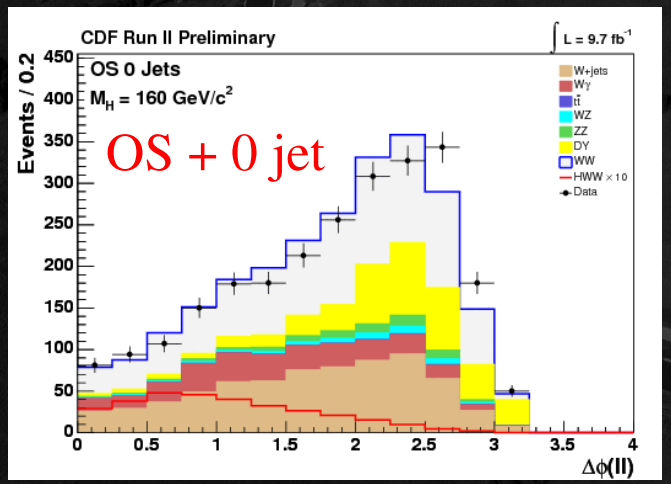


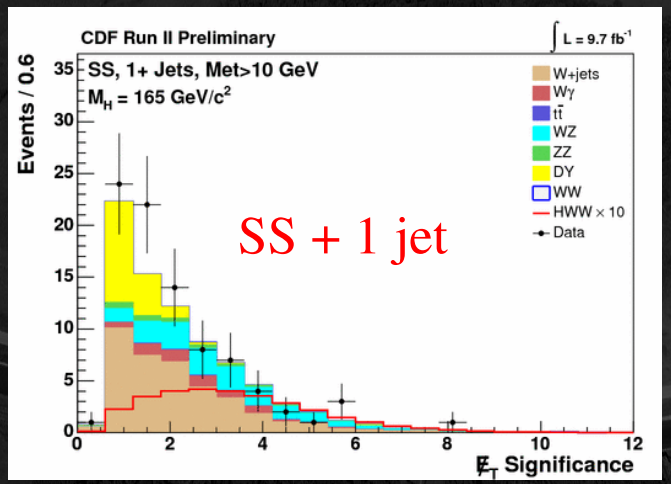


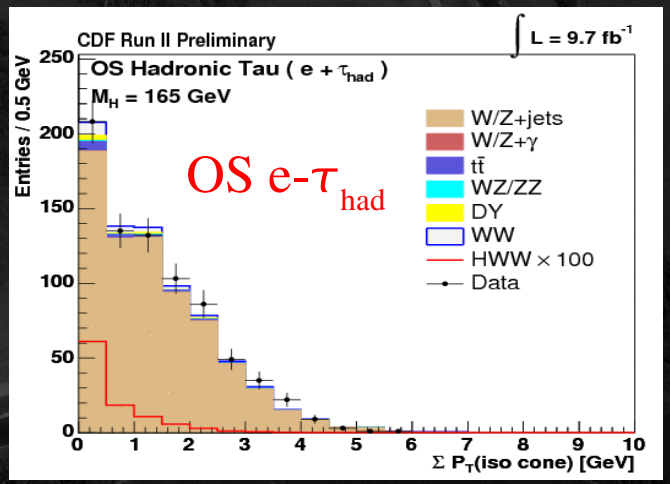
- Modeling and analysis procedure further validated by measuring the diboson production cross sections in the search sample with the same methods.

Signal-background discrimination

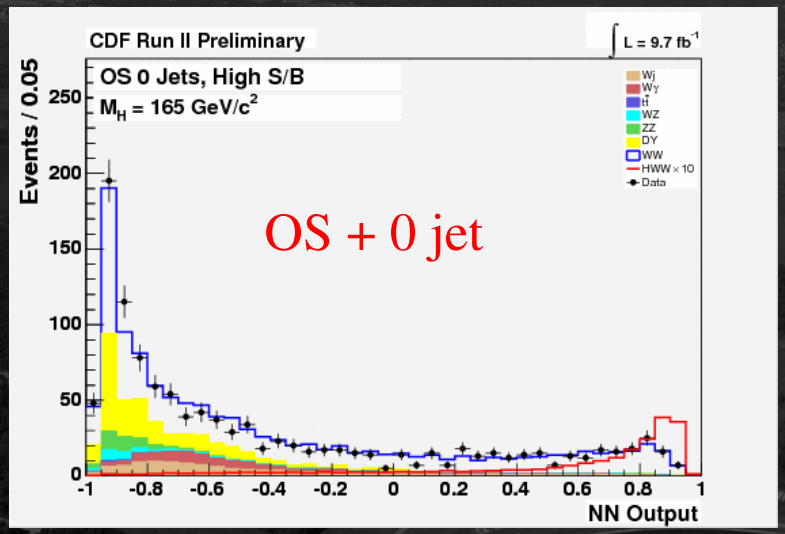
- We are looking for a small signal out of an overwhelming background: across the search samples signal/background ratio ~1/80-1/500.
- Advanced MVA techniques (ANN and BDT) allow to better utilize the event information to maximize the signal-background discrimination:
  - ANN and BDT trained on signal vs backgrounds;
  - kinematical, event-global and particle-identification variables used as inputs to the MVA algorithms;
  - separate MVAs for 19 test Higgs masses.

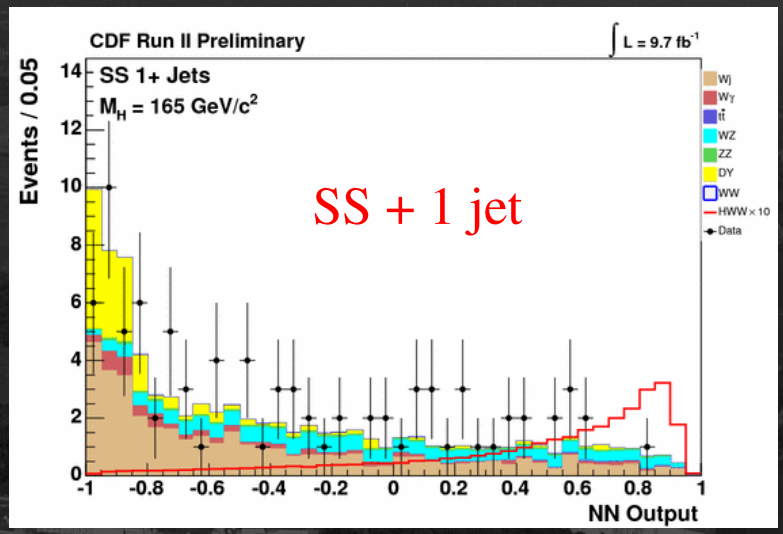


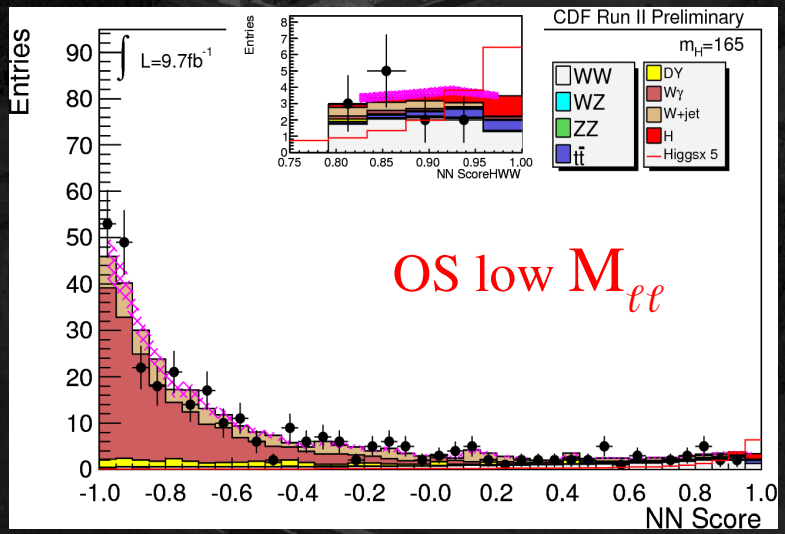


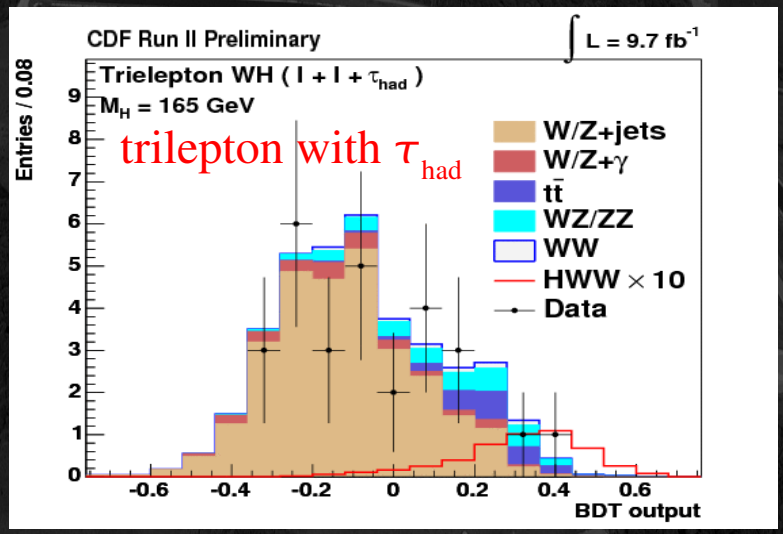


MVA output distributions





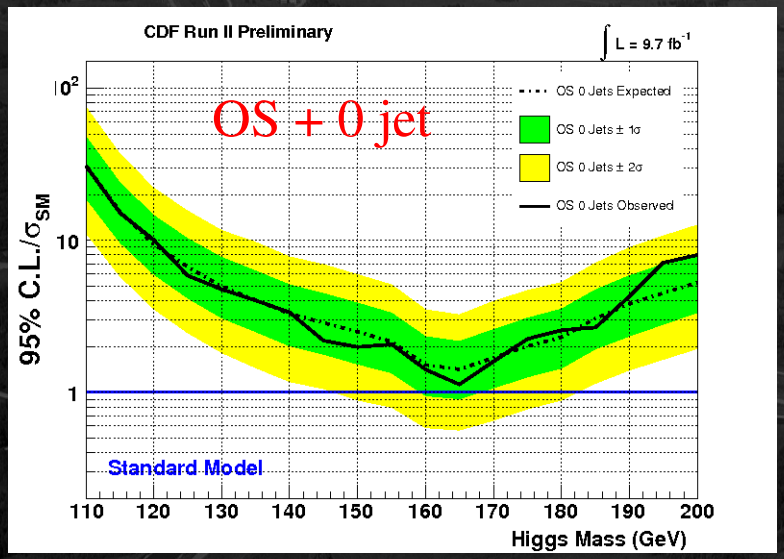


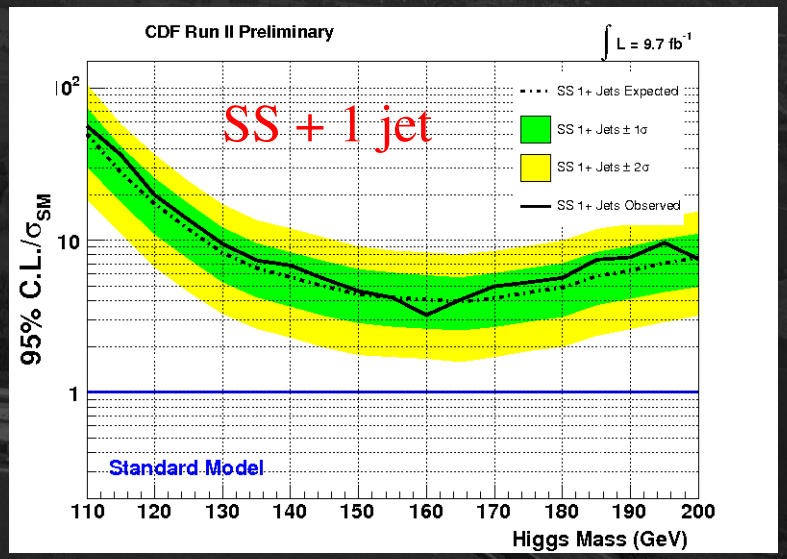


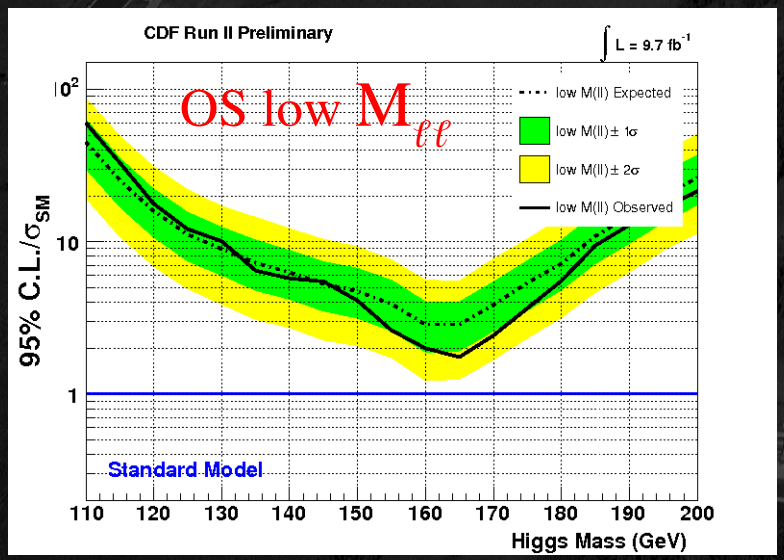
- Since no significant excess is seen in the high score region, the MVA output distributions are used to set upper limits on the SM Higgs production σ_H.

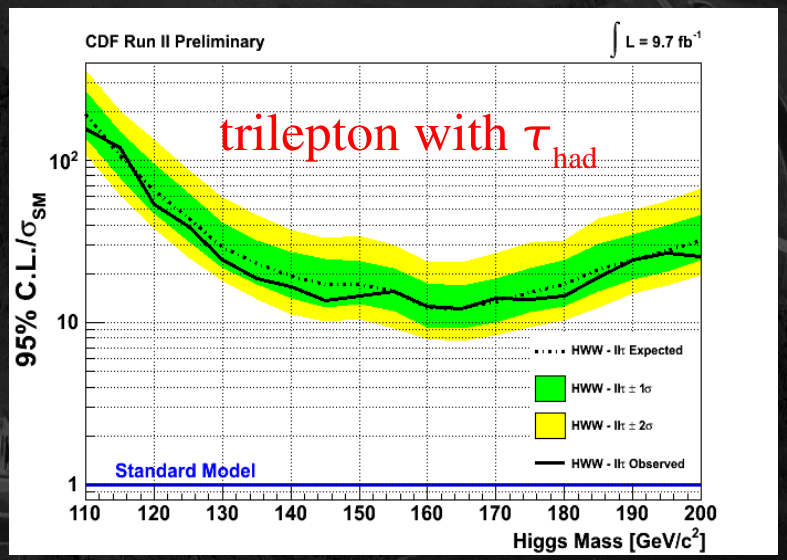
Results

- 95% C.L. upper limits of individual search channels:

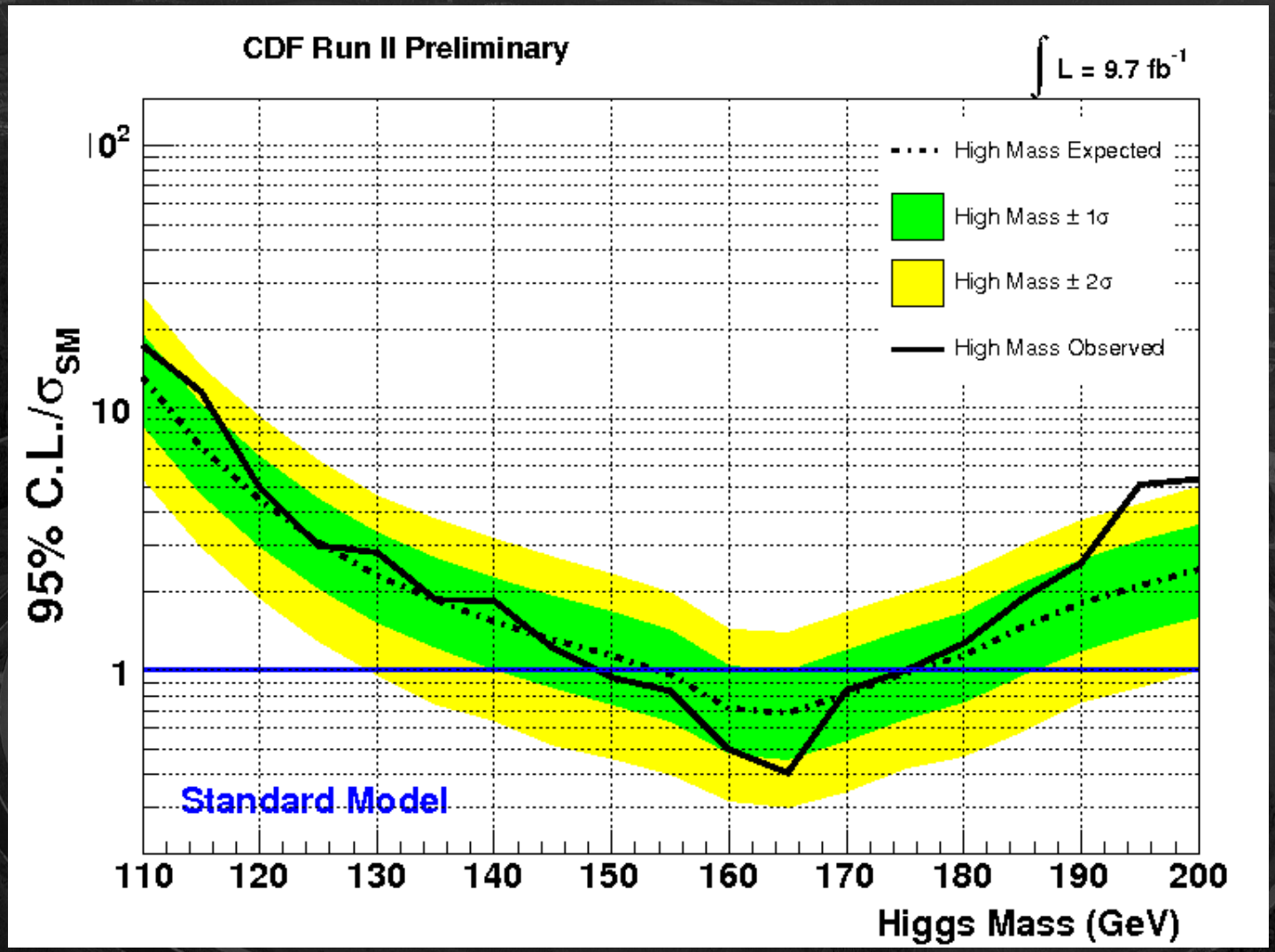








H → WW combined limit



Excluded at 95% C.L. the mass range $148 < m_H < 175$ GeV/c^2

(expected exclusion in absence of signal $154 < m_H < 176$ GeV/c^2 at 95% C.L.)

Conclusions

- The full CDF Run II dataset, corresponding to ~10 fb^{-1} of data, has been analysed in search of a $H \rightarrow WW$ signal over the mass range $110 < m_H < 200$ GeV/c^2.

- The combined analysis achieves sensitivity to the expected SM Higgs production cross section around $m_H = 165$ GeV/c^2.

- No evidence for a signal is found and upper limits are set on the SM Higgs production cross section, which exclude at 95% C.L. the mass range:

$$148 < m_H < 175 \text{ GeV}/c^2.$$


The end.